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D'INGÉNIERIE ET DE GESTION
DU CANTON DE VAUD

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04 - Persistence tier (1)

The DAO pattern & JDBC

AMT 2018

Olivier Liechti

Webcasts

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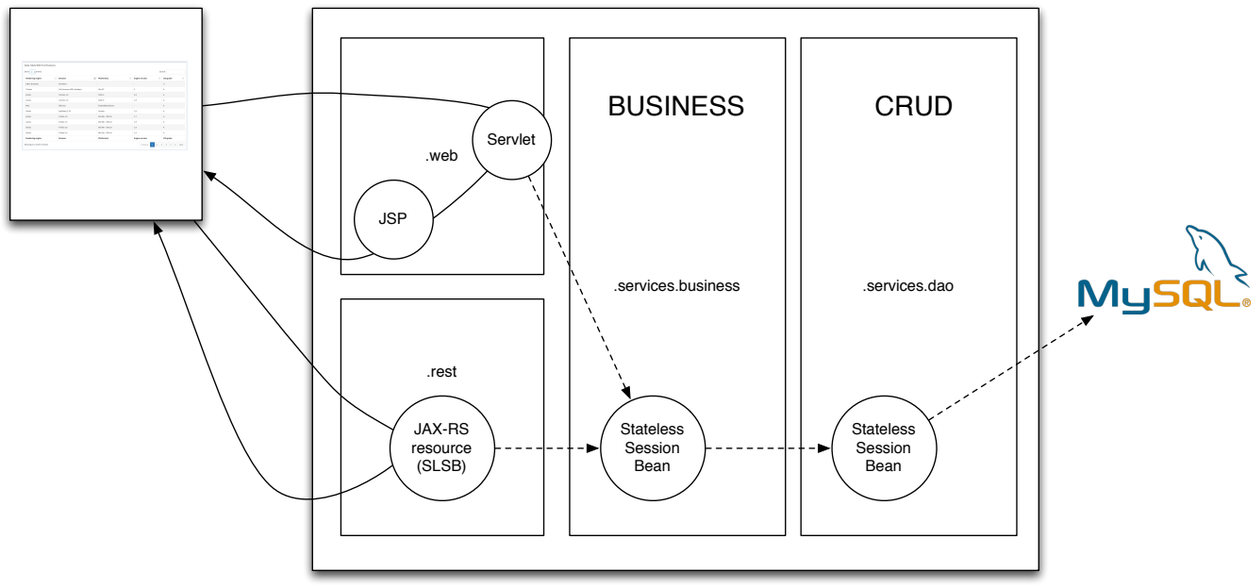

Why are data source useful in Java EE?
What is JDBC and what is its relationship with Java EE?
What is a DAO?

Tasks

1. Prepare the environment
1.1. add a MySQL image to our Docker topology
1.2. add a PhpMyAdmin image to our Docker topology
1.3. insert sample data into our database

2. Configure Glassfish (manually)
2.1. Install MySQL driver
2.2. Configure connection pool and data source

3. Configure Glassfish (Docker)
3.1. Install MySQL driver
3.2. Configure connection pool and data source

4. Configure Wildfly (manually)
4.1. Install MySQL driver
4.2. Configure data source

5. Configure Wildfly (Docker)
5.1. Install MySQL driver
5.2. Configure data source

6. Implement a Data Access Object (DAO)
6.1. Create a new Stateless Session Bean (SLSB)
6.2. Inject the data source into the SLSB
6.3. Use JDBC to send SQL queries to the DB

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17		**Bootcamp 4.1: Intro aux webcasts "tiers d'accès aux données avec JDBC"** by oliechti	4:07
18		**Bootcamp 4.2: ajout de mysql et phpmyadmin dans notre topologie docker-compose** by oliechti	10:53
19		**Bootcamp 4.3: configuration de Glassfish** by oliechti	17:20
20		**Bootcamp 4.4: configuration de la data source dans Docker** by oliechti	8:00
21		**Bootcamp 4.5: configuration de Wildfly via l'interface web** by oliechti	7:16
22		**Bootcamp 4.6: configuration de Wildfly via Docker** by oliechti	24:30
23		**Bootcamp 4.7: écriture du code et test dans Glassfish** by oliechti	8:17

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The DAO Design Pattern

What is the **DAO design pattern** and what are its benefits?

- Most applications manipulate data that is stored in one or more **data stores**.
- There are **different ways** to implement a data store. Think about specific RDMS, NoSQL DBs, LDAP servers, file systems, etc.
- When you implement business logic, you would like to create code that is **independent** from a particular data store implementation (*).
- In other words, you want to **reduce coupling** between your business service and your data store implementation.
- When you apply the **Data Access Object** design pattern, you create an abstraction layer to achieve this goal.

(*) This is true only to some extent… you cannot completely forget about it, for instance for performance reasons

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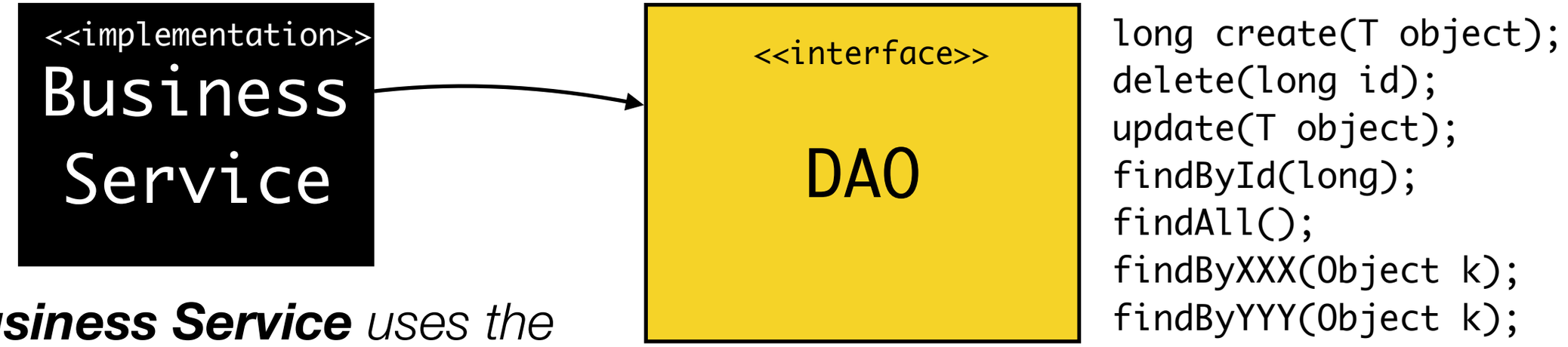
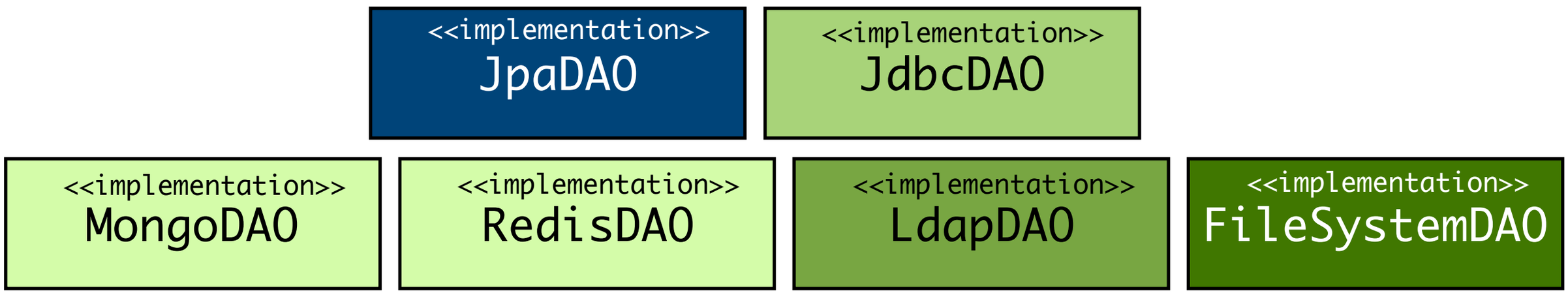
*The **DAO interface** defines generic **CRUD** operations and **finder** methods*

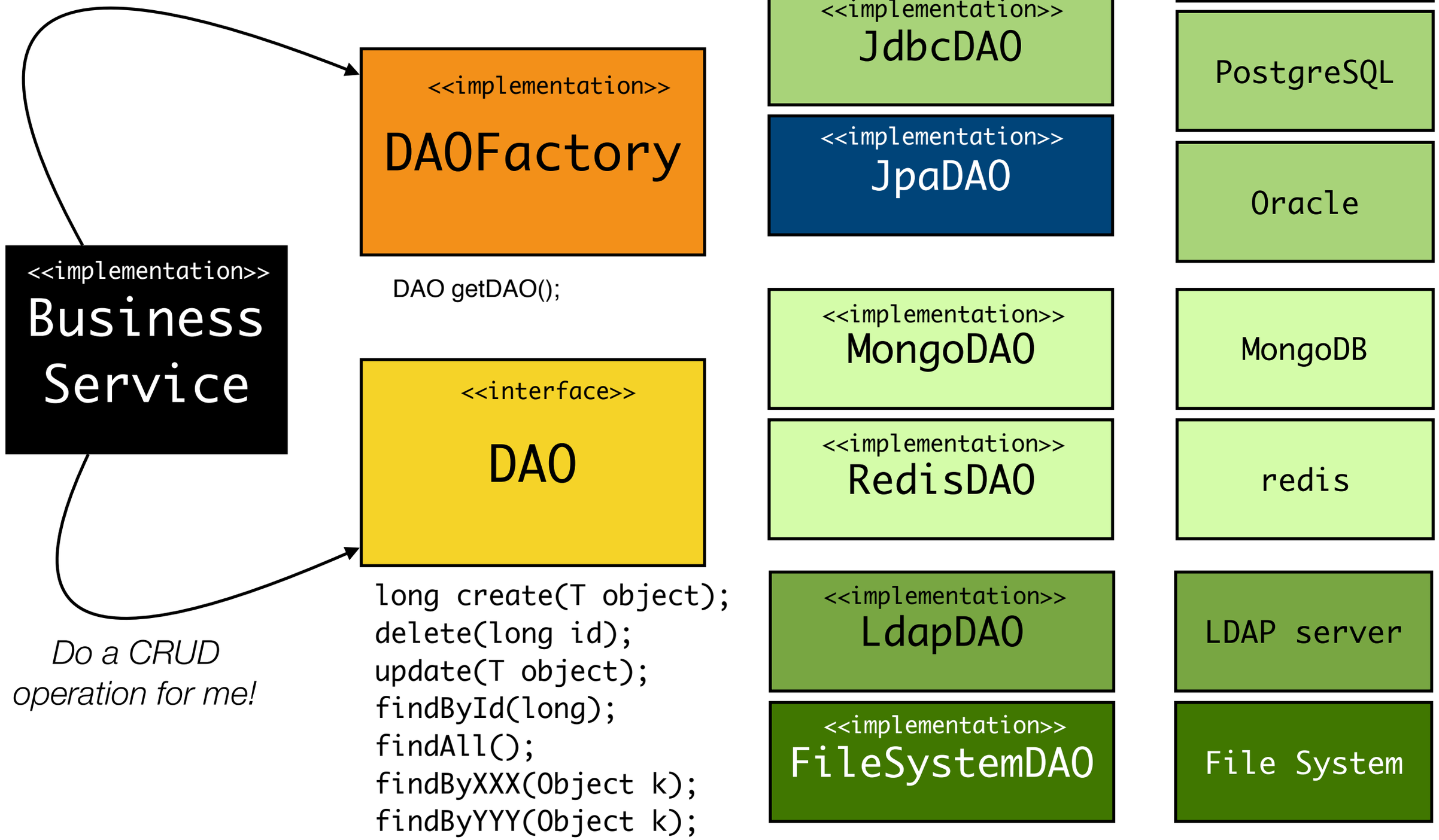


*The **Business Service** uses the DAO interface to interact with a particular DAO implementation*

***DAO implementations** handle interactions with specific data stores*



Give me a DAO implementation!



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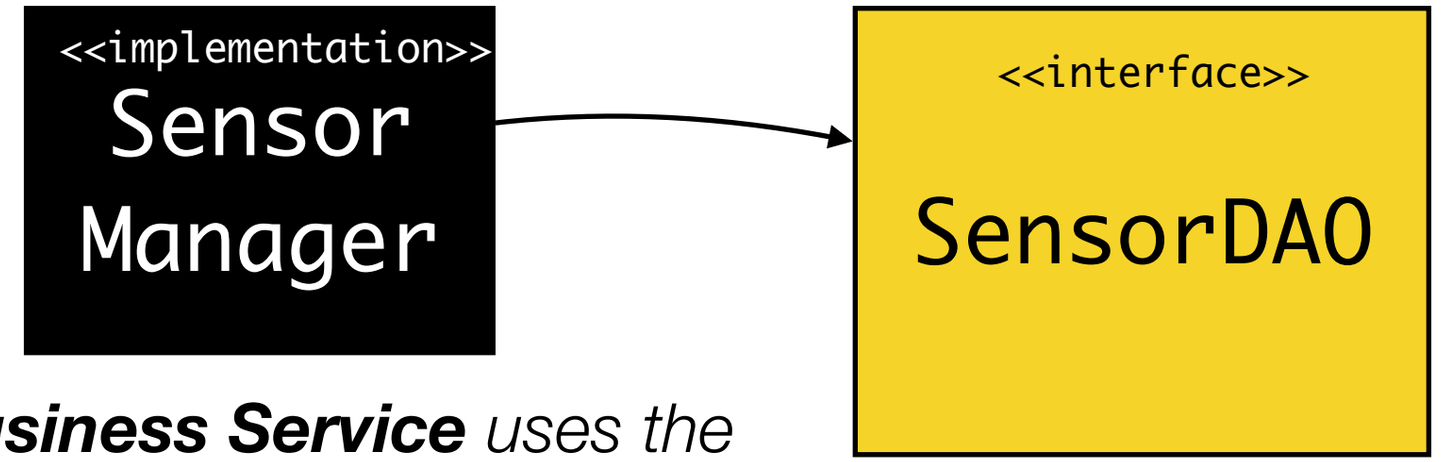
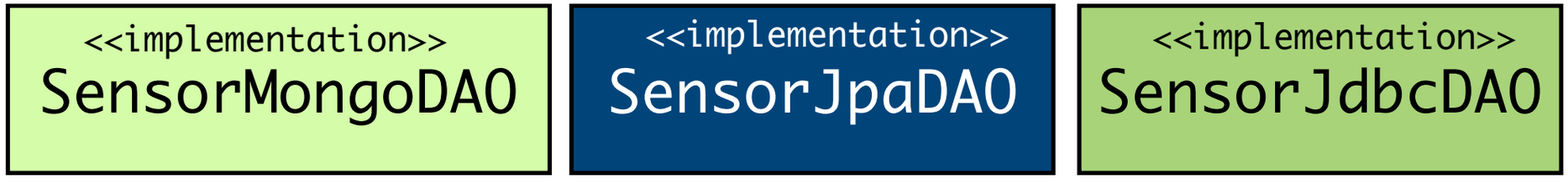
*The **DAO interface** defines generic **CRUD** operations and **finder** methods*



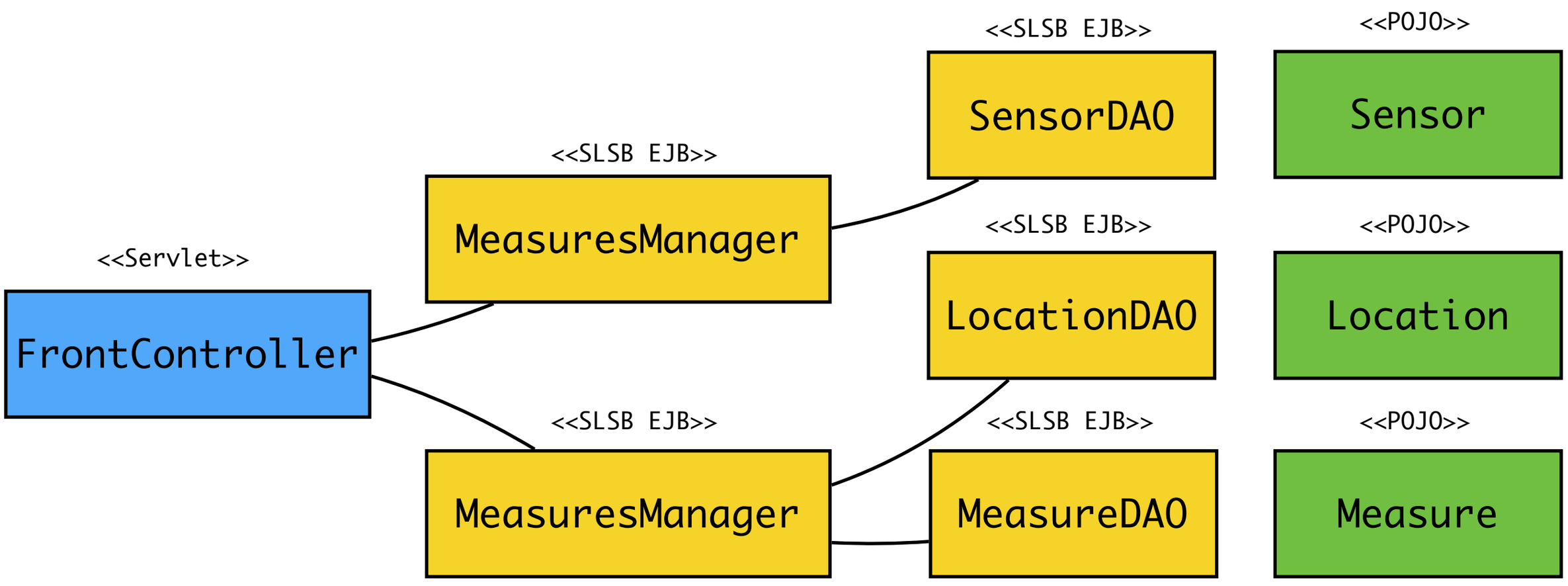
*The **Business Service** uses the DAO interface to interact with a particular DAO implementation*

***DAO implementations** handle interactions with specific data stores*



How do I implement the DAO pattern with Java EE technologies?

- There are **different ways to do it**. Some frameworks (e.g. Spring) do that in the web tier (with POJOs).
- If you use **EJBs**, then your architecture is going to look like this:



Is it possible to have **two EJB classes** that implement the **same interface**?

- In the examples so far (and in most cases in practice), we have always created **one local interface** and **one stateless session bean class**.
- If we define the **DAO interface as a local interface** and implement two stateless session beans (JdbcDAO and JpaDAO), then we have an issue:

The **container is unable to resolve this dependency**, because there is more than one implementation. Which one should it choose?

```
public class MyServlet extends HttpServlet
{
  @EJB
  SensorDAOLocal sensorDAO;
}
```

```
@Local
public interface SensorDAOLocal {
  public long insert(Sensor sensor);
}
```

```
@Stateless
public class SensorJdbcDAO {
          implements SensorDAOLocal
  public long insert(Sensor sensor){}
}
```

```
@Stateless
public class SensorJpaDAO {
          implements SensorDAOLocal
  public long insert(Sensor sensor){}
}
```

Is it possible to have **two EJB classes** that implement the **same interface**?

- We can help the container by giving additional information in the annotation.
- If we define the **DAO interface as a local interface** and implement two stateless session beans (JdbcDAO and JpaDAO), then we have an issue:

The **name**, **beanName** and **mappedName** annotation attributes have different purposes.

```
public class MyServlet extends HttpServlet {
  @EJB(beanName="SensorJdbcDAO")
  SensorDAOLocal sensorDAO;
}
```

```
@Local
public interface SensorDAOLocal {
  public long insert(Sensor sensor);
}
```

```
@Stateless
public class SensorJdbcDAO {
          implements SensorDAOLocal
  public long insert(Sensor sensor){}
}
```

```
@Stateless
public class SensorJpaDAO {
          implements SensorDAOLocal
  public long insert(Sensor sensor){}
}
```

DAO in the MVCDemo Project

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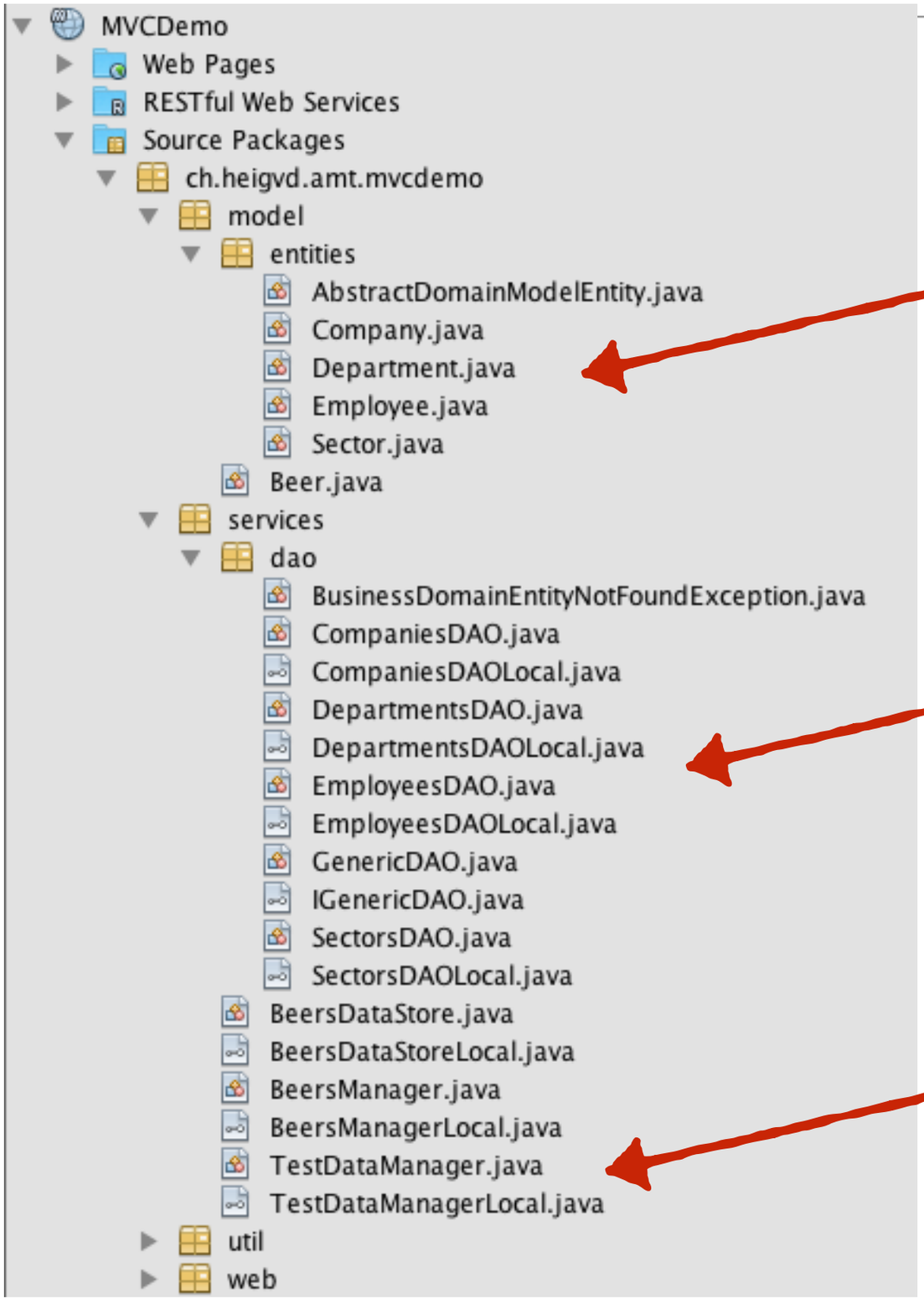

These are the model classes, which can be used with different DAO implementations

These are the DAOs. We only have one implementation, based on JPA.

We use the DAOs to generate test data

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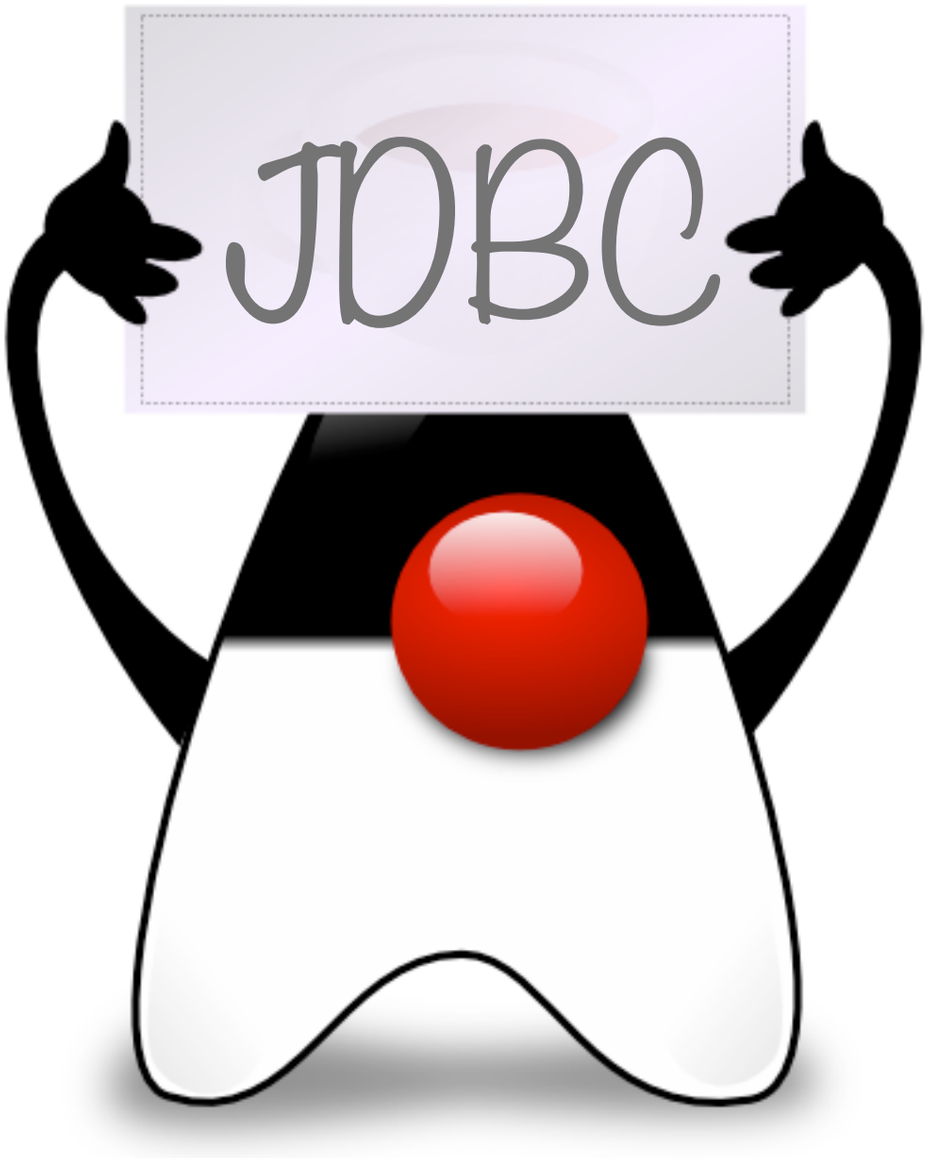


Java DataBase Connectivity

What is **JDBC**?

- The **Java DataBase Connectivity** is a specification that defines how applications can interact with **relational database** management systems in a **standard way**.
- Its goal is to **create an abstraction layer** between applications and specific RDBMS (MySQL, Oracle, PostgresSQL, DB2, etc.).
- Through this abstraction layer, applications can **submit SQL queries to read**, **insert**, **update** and **delete** records in tables.
- Applications can also get **metadata** about the relational schema (table names, column names, etc.).

What does it look like?

```
@Stateless
public class SensorJdbcDAO implements SensorDAOLocal {

  @Resource(lookup = "jdbc/AMTDatabase")
  private DataSource dataSource;

 public List<Sensor> findAll() {
    List<Sensor> result = new LinkedList<>();
    try {
      Connection con = dataSource.getConnection();

    PreparedStatement ps = con.prepareStatement("SELECT * FROM Sensors");
    ResultSet rs = ps.executeQuery();

    while (rs.next()) {
      Sensor sensor = new Sensor();
      sensor.setId(rs.getLong("ID"));
      sensor.setDescription(rs.getString("DESCRIPTION"));
      sensor.setType(rs.getString("TYPE"));
      result.add(sensor);
    }

    ps.close();
    con.close();

  } catch (SQLException ex) {
    Logger.getLogger(SensorJdbcDAO.class.getName()).log(Level.SEVERE, null, ex);
  }
  return result;
}
```

dependency injection

get a connection from the pool

create and submit a SQL query

scroll through the tabular result set

get data from the result set

return the connection to the pool

What is **JDBC**?

JDBC API

java[x].sql.* interfaces

JDBC Service (provided by JRE)

java[x].sql.* classes

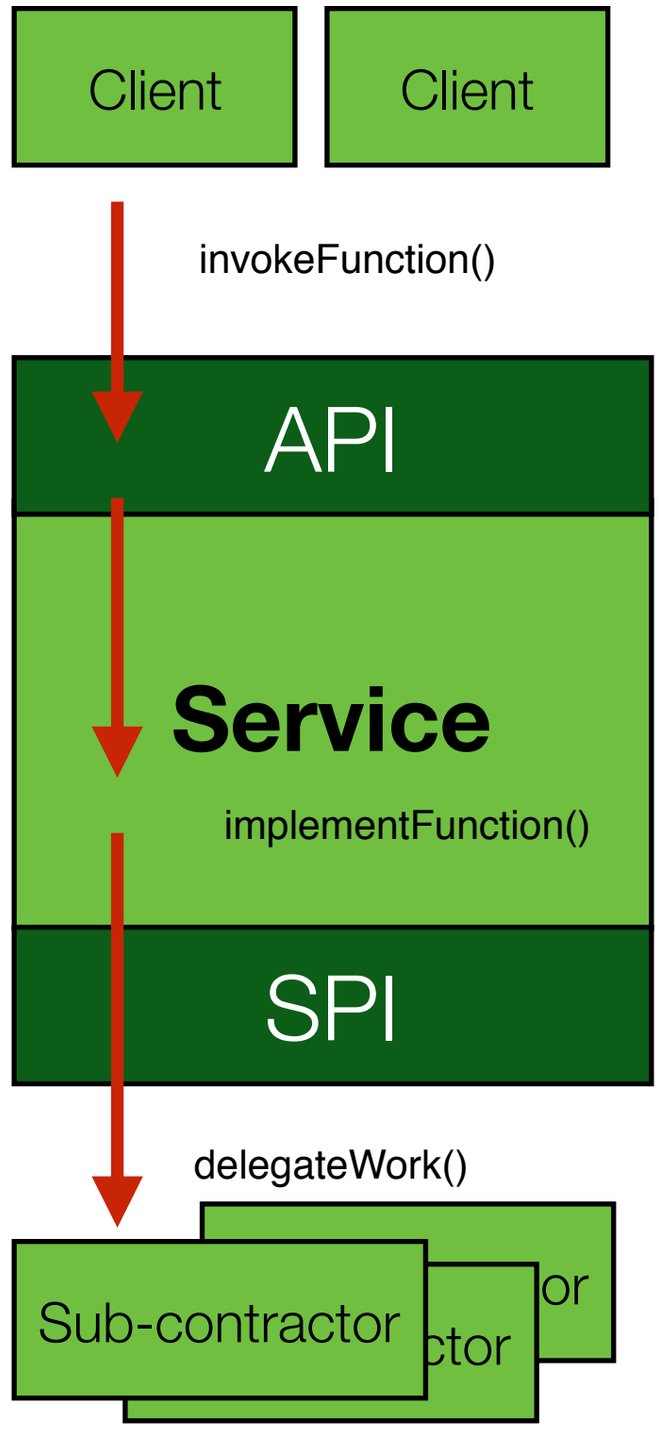
JDBC SPI (extends JDBC API)

JDBC MySQL driver

implements java[x].sql.* interfaces

What is the difference between an **API** and a **SPI**?

- An **Application Programming Interface** (API) is a **contract** between a client and a service.
- It **defines what the client can request** from the service.
- A **Service Provider API** (SPI) is a contract between a service and its **subcontractors** (components to which it delegates some of the work).
- It **defines what the subcontractors need to do** in order to receive work from the service.



What is the difference between an **API** and a **SPI**?

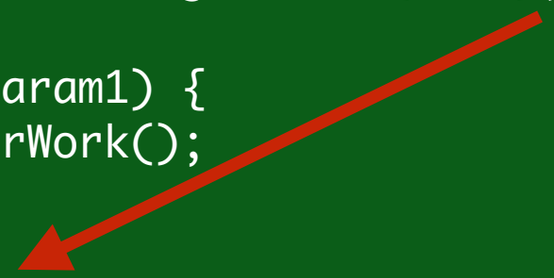
```
public interface ServiceAPI {
  public void invokeFunction1();
  public String invokeFunction2(Object param1);
}
```

```
public class Service implements ServiceAPI {
  private ServiceSPI provider;

  public void invokeFunction1() { provider.delegateWork(null); };

  public String invokeFunction2(Object param1) {
    doSomething(); provider.delegateOtherWork();
  }

  public void registerServiceProvider(ServiceSPI provider) {
    this.provider = provider
  }
}
```



```
public interface ServiceSPI {
  public void delegateWork(String[] params);
  public void delegateOtherWork();
  public void doSomething();
}
```

In some cases, the SPI is an **extension** of the API.

```
public interface ServiceAPI {
  public void invokeFunction1();
  public String invokeFunction2(Object param1);
}
```

```
public class Service implements ServiceAPI {
  private ServiceSPI provider;

  public void invokeFunction1() { provider.invokeFunction1(); };

  public String invokeFunction2(Object param1) {
    provider.invokeFunction2(param1); provider.doSomethingNotExposedInAPI();
  }

  public void registerServiceProvider(ServiceSPI provider) {
    this.provider = provider
  }
}
```

```
public interface ServiceSPI extends ServiceAPI {
  public void doSomethingNotExposedInAPI();
}
```

How is it possible to **obtain a reference** to a JDBC service provider (driver)?

- At some point, the application wants to **obtain a reference to a specific provider**, so that that it can invoke JDBC functions.
- The method depends on the Java environment. You do not the same thing if you are in a **Java SE** or **Java EE** environment.

Java SE

`java.sql.DriverManager`

*Think "**explicit** class loading and connection URLs"*

Java EE

`java.sql.DataSource`

*Think "**managed** resources and "dependency injection"*

How do I **obtain a reference** to a JDBC service provider in **Java SE**?

- In Java SE, the **DriverManager** class addresses this need:
  - It is used by clients who use the API.
  - It is also used by drivers who implement the SPI.
- Think of it as a **broker**, or a **registry**, who puts clients and service providers in relation.
- As a client, I am **explicitly** loading JDBC drivers (1 or more).
- As a client, I am **explicitly** telling with which database I want to interact (via a URL). The URL is used both to find a proper driver and to establish a connection (e.g. hostname, port, etc.).

How do I **obtain a reference** to a JDBC service provider in **Java SE**?

- From the specifications: “Key **DriverManager** methods include:

1. A service provider registers itself in the directory.

  - **registerDriver** — this method **adds a driver to the set of available drivers** and is invoked implicitly when the driver is loaded. The registerDriver method is typically called by the static initializer provided **by each driver**.

Used by **SPI** implementations

  - **getConnection** — the method the **JDBC client** invokes to establish a connection. The invocation includes a JDBC URL, which the DriverManager passes to each driver in its list until it finds one whose Driver.connect method recognizes the URL. That driver returns a Connection object to the DriverManager, which in turn passes it to the application.”

Used by **API** clients

2. A client looks for a service provider in the directory.

How do I **obtain a reference** to a JDBC service provider in **Java SE**?

Client

```
Class.forName("ch.heigdb.HeigDbDriver");
DriverManager.getConnection("jdbc:heigdb://localhost:2205");
```

JDBC Service (provided by JRE)

```
java.sql.DriverManager
registerDriver(Driver driver)
Connection getConnection(String url)
```

JDBC HeigDB driver

```
public class HeigDbDriver implements java.sql.Driver {

    static {
        DriverManager.registerDriver(new SomeDriver());
    }
    public boolean acceptsURL(String url) {};
    public Connection connect(String url, Properties p) {};
}
```

1. Load a class
2. "I am an SPI provider"
3. "Find a SPI provider that will connect me to this DB"
4. "Can you connect me with this DB?"
5. "Connect me with this DB"

How do I **obtain a reference** to a JDBC service provider in **Java EE**?

- In Java EE, the **DataSource** interface is used for managing DB connections.
  - It is used by **application components** (servlets, EJBs, etc.) to obtain a connection to a database.
  - It is also used by **system administrators**, who define the **mapping** between a logical data source name and a concrete database system (by configuration).
- As a developer, I am only using a logical name and I know that it will be bound to a specific system at runtime (but I don't care which…).
- As a developer, I obtain a DataSource either by doing a **JNDI lookup** or via **dependency injection** (with annotations).

How do I **obtain a reference** to a JDBC service provider in **Java EE**?

Client

```
Context ctx = new InitialContext();
DataSource ds = (DataSource)ctx.lookup("jdbc/theAppDatabase");
```

OR

3
```
@Resource(lookup="jdbc/theAppDatabase")
DataSource ds;
```

4
```
ds.getConnection();
```

JDBC Service (provided by Java EE)

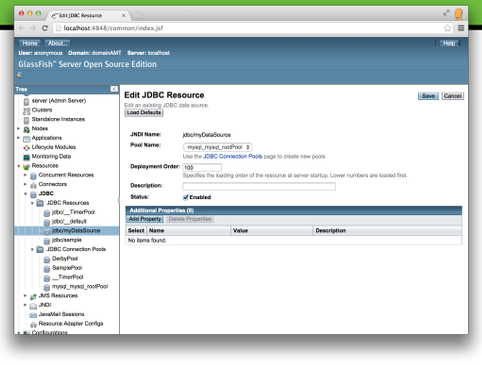
java.sql.DataSource

mysql-connector-java-5.1.33.jar

1

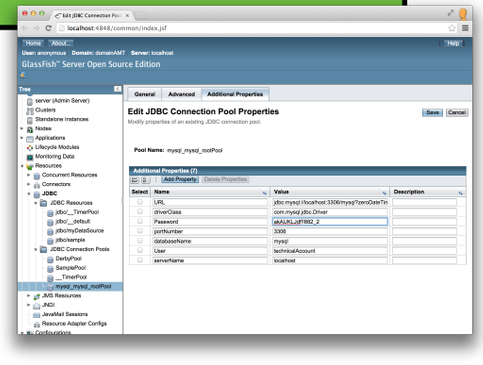
Install a **driver** (.jar file) in the app server (/lib/)

2



Create a (logical) data source…

3



… and map it to a (physical) connection pool

Edit JDBC Resource

localhost:4848/common/index.jsf

Home | About... | Help

User: anonymous | **Domain:** domainAMT | **Server:** localhost

GlassFish™ Server Open Source Edition

Tree

- server (Admin Server)
- Clusters
- Standalone Instances
- Nodes
- Applications
- Lifecycle Modules
- Monitoring Data
- Resources
  - Concurrent Resources
  - Connectors
  - **JDBC**
    - JDBC Resources
      - jdbc/__TimerPool
      - jdbc/__default
      - jdbc/myDataSource
      - jdbc/sample
    - JDBC Connection Pools
      - DerbyPool
      - SamplePool
      - __TimerPool
      - mysql_mysql_rootPool
  - JMS Resources
  - JNDI
  - JavaMail Sessions
  - Resource Adapter Configs
- Configurations

Edit JDBC Resource

Save | Cancel

Edit an existing JDBC data source.

Load Defaults

JNDI Name: jdbc/myDataSource

Pool Name: mysql_mysql_rootPool

Use the JDBC Connection Pools page to create new pools

Deployment Order: 100

Specifies the loading order of the resource at server startup. Lower numbers are loaded first.

Description:

Status: Enabled

Additional Properties (0)

Add Property | Delete Properties

Select	Name	Value	Description
No items found.			

A **JDBC Resource** simply defines a **mapping** between a **logical name** (used in the code) and a **concrete DB connection pool** (hooked to a “physical” DB).

Edit JDBC Connection Pool

localhost:4848/common/index.jsf

Home | About... | Help

User: anonymous | **Domain:** domainAMT | **Server:** localhost

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      - mysql_mysql_rootPool
  - JMS Resources
  - JNDI
  - JavaMail Sessions
  - Resource Adapter Configs
- Configurations

General | **Advanced** | **Additional Properties**

Edit JDBC Connection Pool Properties

Save Cancel

Modify properties of an existing JDBC connection pool.

Pool Name: mysql_mysql_rootPool

Additional Properties (7)

Add Property | Delete Properties

Select	Name	Value	Description
☐	URL	jdbc:mysql://localhost:3306/mysql?zeroDateTin	
☐	driverClass	com.mysql.jdbc.Driver	
☐	Password	akAUKLJdf!!882_2	
☐	portNumber	3306	
☐	databaseName	mysql	
☐	User	technicalAccount	
☐	serverName	localhost	

The **connection pool** is configured with “physical” database attributes (host, port, credentials, etc.).

What are some of the key JDBC interfaces and classes?

DriverManager

DataSource

XADataSource

Connection

PreparedStatement

ResultSet

ResultSetMetaData

- **DriverManager** and **DataSource** variations provide a means to obtain a **Connection**.
- **XADataSource** is used for distributed transactions.
- Once you have a **Connection**, you can submit SQL queries to the database.
- The most common way to do that is to create a **PreparedStatement** (rather than a **Statement**, which is useful for DDL commands).
- The response is either a number (number of rows modified by an UPDATE or DELETE query), or a **ResultSet** (which is a tabular data set).
- **ResultSetMetadata** is a way to obtain information about the returned data set (column names, etc.).

How do I use these classes in my code?

```
@Stateless
public class SensorJdbcDAO implements SensorDAOLocal {

  @Resource(lookup = "jdbc/AMTDatabase")
  private DataSource dataSource;

 public List<Sensor> findAll() {
    List<Sensor> result = new LinkedList<>();
    try {
      Connection con = dataSource.getConnection();

    PreparedStatement ps = con.prepareStatement("SELECT * FROM Sensors");
    ResultSet rs = ps.executeQuery();

    while (rs.next()) {
      Sensor sensor = new Sensor();
      sensor.setId(rs.getLong("ID"));
      sensor.setDescription(rs.getString("DESCRIPTION"));
      sensor.setType(rs.getString("TYPE"));
      result.add(sensor);
    }

    ps.close();
    con.close();

  } catch (SQLException ex) {
    Logger.getLogger(SensorJdbcDAO.class.getName()).log(Level.SEVERE, null, ex);
  }
  return result;
}
```

dependency injection

get a connection from the pool

create and submit a SQL query

scroll through the tabular result set

get data from the result set

return the connection to the pool

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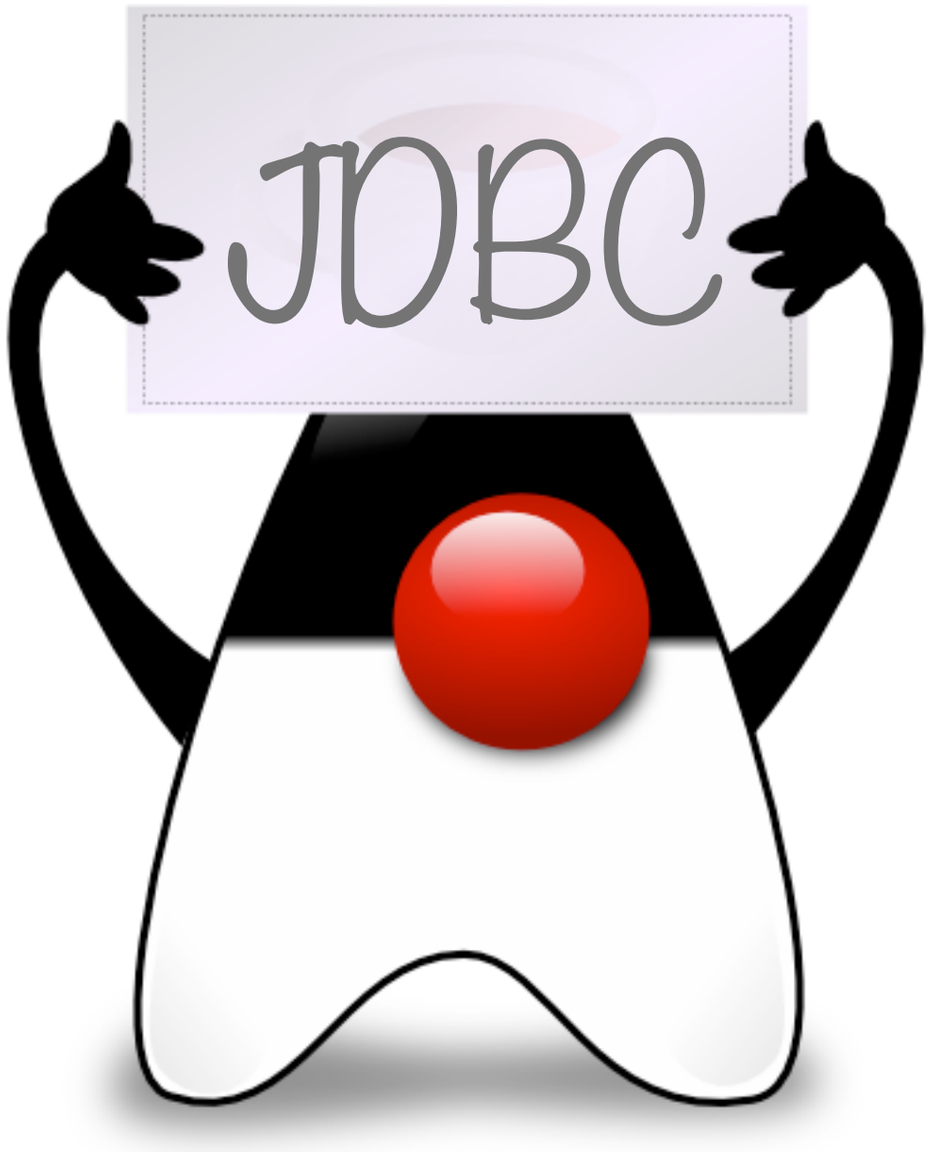

Let’s apply that to the project

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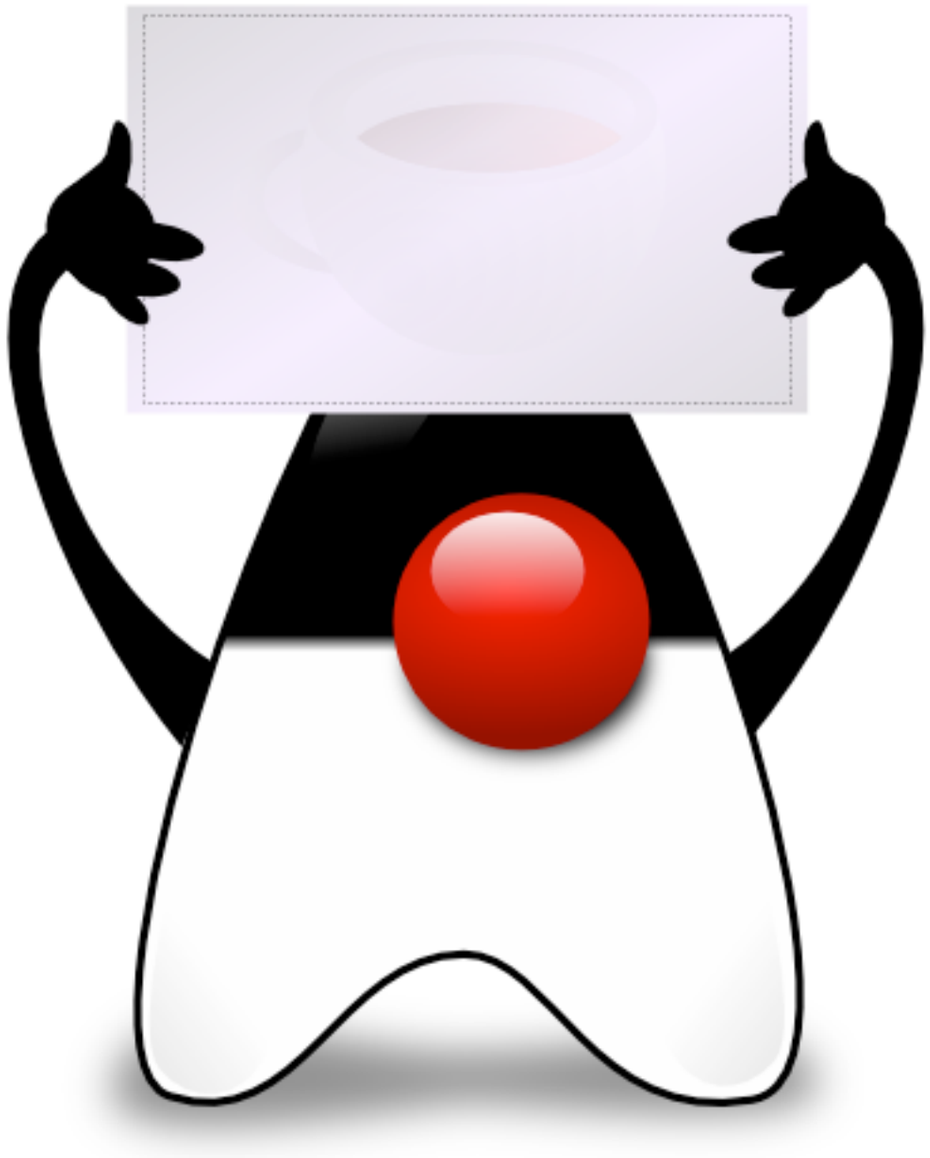

JDBC without copy-paste

JDBC is pretty straightforward, but… isn't it **verbose and repetitive**?

```
@Stateless
public class SensorJdbcDAO implements SensorDAOLocal {

  @Resource(lookup = "jdbc/AMTDatabase")
  private DataSource dataSource;

 public List<Sensor> findAll() {
    List<Sensor> result = new LinkedList<>();
    try {
      Connection con = dataSource.getConnection();

      PreparedStatement ps = con.prepareStatement("SELECT * FROM Sensors");
      ResultSet rs = ps.executeQuery();

      while (rs.next()) {
        Sensor sensor = new Sensor();
        sensor.setId(rs.getLong("ID"));
        sensor.setDescription(rs.getString("DESCRIPTION"));
        sensor.setType(rs.getString("TYPE"));
        result.add(sensor);
      }

      ps.close();
      con.close();

    } catch (SQLException ex) {
      Logger.getLogger(SensorJdbcDAO.class.getName()).log(Level.SEVERE, null, ex);
    }
    return result;
}
```

When I implement the UserDAO, the RoleDAO, the LocationDAO, will I need to **repeat** all the code around those statements (**boilerplate**)?

Will I need to manually replace the **table and column names** in each DAO?

And when I **maintain** my application, what happens when a new property is added? Do I have to **update my DAO**?

```java
@Stateless
public class SensorJdbcDAO implements SensorDAOLocal {

  @Resource(lookup = "jdbc/AMTDatabase")
  private DataSource dataSource;

 public List<Sensor> findAll() {
    List<Sensor> result = new LinkedList<>();
    try {
      Connection con = dataSource.getConnection();

      PreparedStatement ps = con.prepareStatement("SELECT * FROM Sensors");
      ResultSet rs = ps.executeQuery();

      while (rs.next()) {
        Sensor sensor = new Sensor();
        sensor.setId(rs.getLong("ID"));
        sensor.setDescription(rs.getString("DESCRIPTION"));
        sensor.setType(rs.getString("TYPE"));
        result.add(sensor);
      }

      ps.close();
      con.close();

    } catch (SQLException ex) {
      Logger.getLogger(SensorJdbcDAO.class.getName()).log(Level.SEVERE, null, ex);
    }
    return result;
  }
```

Reflection sounds cool. Can't we use it to deal with JDBC in **more generic** ways?

JDBC gives me **metadata** about the DB schema.

Reflection gives me ways to dynamically find and **invoke methods** on Java objects.

Can we combine these features to make this code better?

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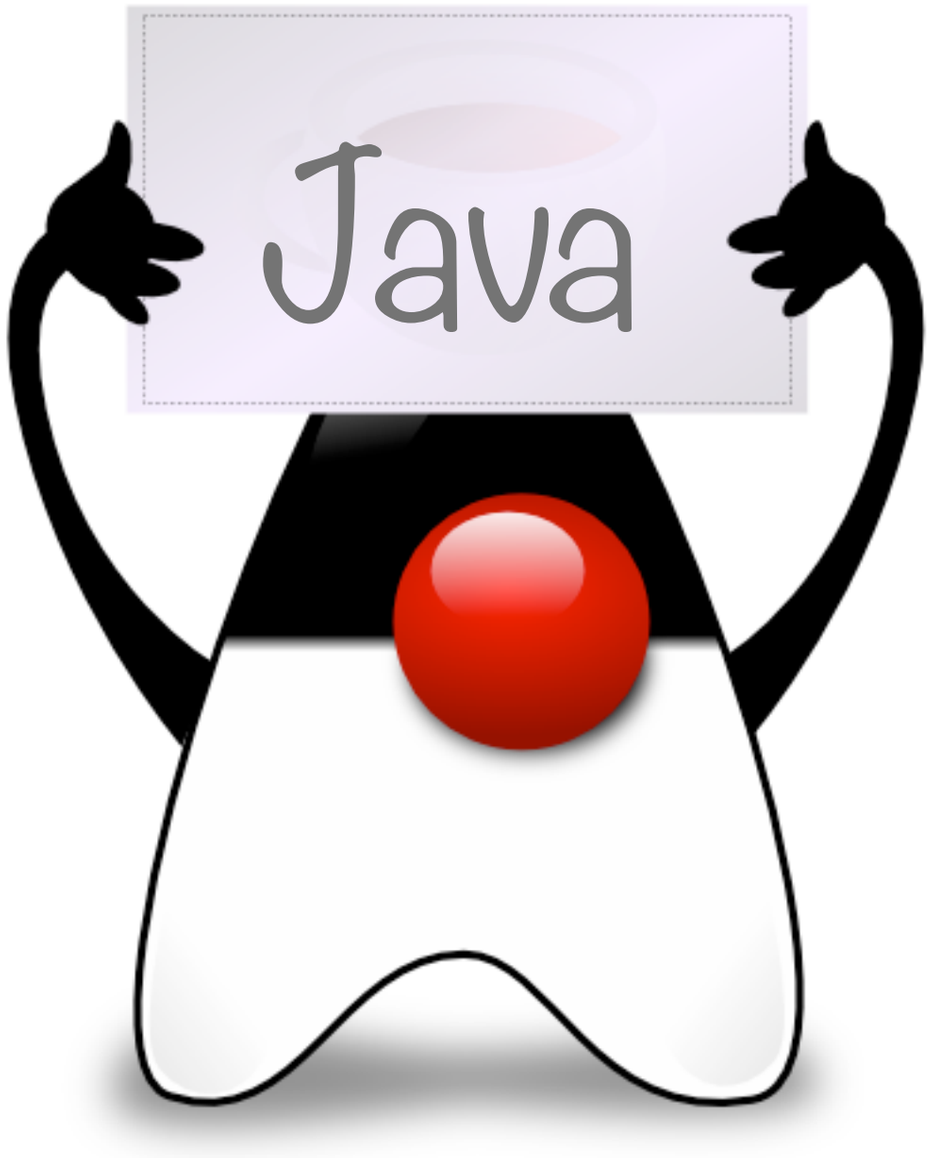
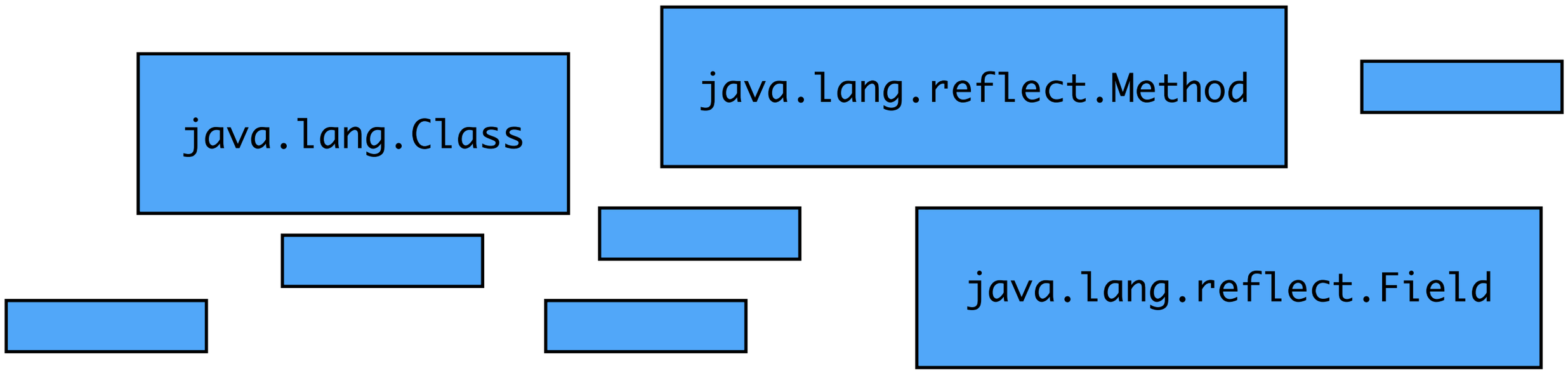


Java Reflection & JavaBeans

What is the Java **Reflection** API?

- Reflection is a mechanism, through which a program can **inspect and manipulate** its structure and behavior **at runtime.**
- In Java, this means that a program can **get information about classes, their fields, their methods, etc.**
- In Java, this also means that a program can **create instances of classes dynamically** (based on their names, as in the example of JDBC drivers), **invoke methods**, etc.



Can you give me an example of **reflective code**?

- We can **load class definitions** and **create instances**, without hard-coding class names into Java identifiers:

```
Class dynamicManagerClass = Class.forName("ch.heigvd.amt.reflection.services.SensorsManager");
Object dynamicManager = dynamicManagerClass.newInstance();
```

- For a class, we can **get the list of methods** and **their signature**:

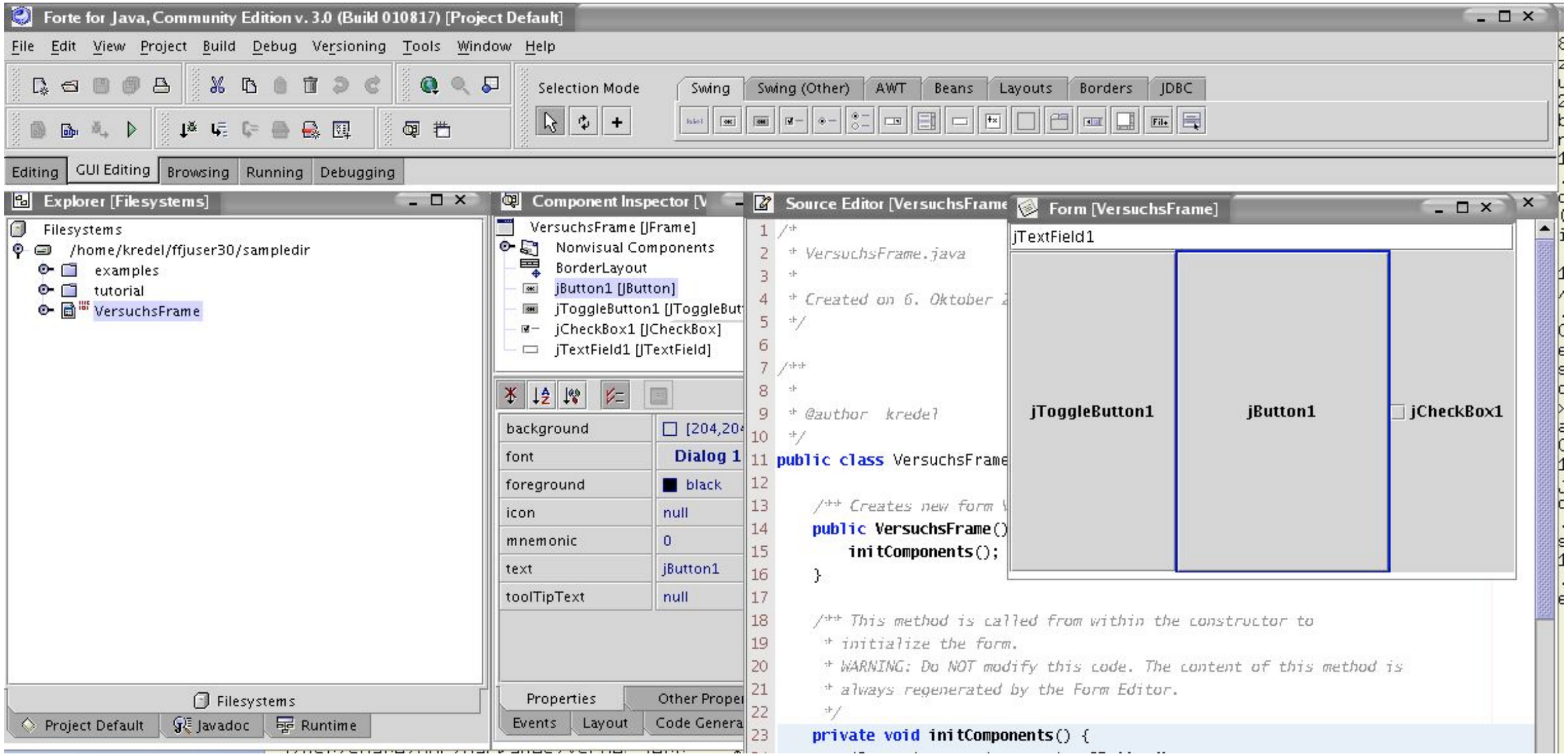
```
Method[] methods = dynamicManagerClass.getMethods();

for (Method method : methods) {
  LOG.log(Level.INFO, "Method name: " + method.getName());

  Parameter[] parameters = method.getParameters();
  for (Parameter p : parameters) {
    LOG.log(Level.INFO, "p.getName()+ ":" + p.getType().getCanonicalName());
  }
}
```

- We can dynamically **invoke a method** on an object:

```
Method method = dynamicManagerClass.getMethod("generateSensors", int.class, String.class);
Object result = method.invoke(dynamicManager, 5, "hello");
```

What are **JavaBeans**?

- First of all, JavaBeans are **NOT** Enterprise Java Beans.
- The JavaBeans specification was proposed a very long time ago (1997) to enable the creation of **reusable components in Java**.
- One of the first use cases was to support the creation of **WYSIWYG development tools**. The programmer could drag and drop a GUI widget from a palette onto a window and edit its properties in a visual editor (think Visual Basic for Java).
- In this scenario, the GUI widgets would be packaged as JavaBeans by **third-party vendors**. The development tool would recognize them as such and would **dynamically extend the palette** of available components.



Forte for Java (aka Netbeans grand-father)

What are **JavaBeans**?

- Since then, JavaBeans have become **pervasive** in the Java Platform and are **used in many other scenarios**.
- This is particularly true in the Java EE Platform. Actually, **you have already implemented** JavaBeans without realizing it.
- While there are other aspects in the specification, the key elements are **coding conventions** that JavaBeans creators should respect:

  1. A JavaBean should have a **public no-args constructor**.
  2. A JavaBean should expose its properties via **getter** and **setter methods** with **well-defined names**.
  3. A JavaBean should be **serializable**.

```java
public class Customer implements Serializable {

  public Customer() {}

  private String firstName;
  private String lastName;
  private boolean goodCustomer;

  public String getFirstName() {
    return firstName;
  }

  public void setFirstName(String firstName) {
    this.firstName = firstName;
  }

  public String getLastName() {
    return lastName;
  }

  public void setLastName(String lastName) {
    this.lastName = lastName;
  }

  public boolean isGoodCustomer() {
    return goodCustomer;
  }

  public void setGoodCustomer(boolean goodCustomer) {
    this.goodCustomer = goodCustomer;
  }

}
```

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There is a **specific convention** for writing getter methods for **boolean properties**.

What are **JavaBeans**?

- These **coding and naming conventions** make it easier to **benefit from reflection** in **Java frameworks**:

    1. The framework can use the **public no-args constructor** to **create instances** with Class.newInstance().
    2. The framework can **easily find out which methods it should call** (via reflection), based on a textual name. For instance, when a JSP page includes the string ${sensor.type}, the runtime knows that it must invoke a method named "get" + "Type".
    3. The **state of a JavaBean** can travel over the wire (for instance when it moves from a remote EJB container to a web container).

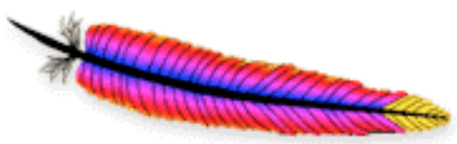
What should I be know if I plan **to implement a framework** with JavaBeans?

- With the naming conventions defined in the JavaBeans specification, combined with Java reflection, **you can do pretty much everything yourself**.

- Have a look at the **java.beans** package and at the **Introspector** class. You will have easy access to properties, getters and setters.

- You should be aware of the **Apache Commons BeanUtils** library that will make your life easier.

*"The Java language provides **Reflection** and **Introspection** APIs (see the java.lang.reflect and java.beans packages in the JDK Javadocs). However, **these APIs can be quite complex** to understand and utilize. The BeanUtils component provides **easy-to-use wrappers** around these capabilities."*



http://commons.apache.org/proper/commons-beanutils/

commons beanutils™

Back to the original question... How can I use reflection to **make my JDBC code generic**?

```
@Stateless
public class SensorJdbcDAO implements SensorDAOLocal {

  @Resource(lookup = "jdbc/AMTDatabase")
  private DataSource dataSource;

 public List<Sensor> findAll() {
    List<Sensor> result = new LinkedList<>();
    try {
      Connection con = dataSource.getConnection();

      PreparedStatement ps = con.prepareStatement("SELECT * FROM Sensors");
      ResultSet rs = ps.executeQuery();

      while (rs.next()) {
        Sensor sensor = new Sensor();
        sensor.setId(rs.getLong("ID"));
        sensor.setDescription(rs.getString("DESCRIPTION"));
        sensor.setType(rs.getString("TYPE"));
        result.add(sensor);
      }

      ps.close();
      con.close();

    } catch (SQLException ex) {
      Logger.getLogger(SensorJdbcDAO.class.getName()).log(Level.SEVERE, null, ex);
    }
    return result;
  }
```

Reflection sounds cool. Can't we use it to deal with JDBC in **more generic** ways?

JDBC gives me **metadata** about the DB schema.

Reflection gives me ways to dynamically find and **invoke methods** on Java objects.

Can we combine these features to make this code better?

Back to the original question... How can I use reflection to **make my JDBC code generic**?

```
Sensor sensor = new Sensor();
sensor.setId(rs.getLong("ID"));
sensor.setDescription(rs.getString("DESCRIPTION"));
sensor.setType(rs.getString("TYPE"));
result.add(sensor);
```

Object-Relational Mapping in this example:
Table name = Class name + “s”
Column name = property name

Class names, property names, table names and column names do not have to be hard-coded.

What we need is a **mapping**. We can either rely on **conventions** or define it **explicitly**.

```
String entityName = "Sensor";
String className = "ch.heigvd.amt.lab1.model." + entityName;
String tableName = entityName + "s";
PreparedStatement ps = con.prepareStatement("SELECT * FROM " + tableName);
ResultSet rs = ps.executeQuery();
Class entityClass = Class.forName(className);
PropertyDescriptor[] properties =
Introspector.getBeanInfo(entityClass).getPropertyDescriptors();

while (rs.next()) {
  Object entity;
  entity = entityClass.newInstance();
  for (PropertyDescriptor property : properties) {
    Method method = property.getWriteMethod();
    String columnName = property.getName();
    try {
      method.invoke(entity, rs.getObject(columnName));
    } catch (SQLException e) {
      LOG.warning("Could not retrieve value for property " + property.getName()
           + " in result set. " + e.getMessage());
    }
  }
  result.add(entity);
}
```

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These mechanisms are used by people who build Object Relational Mapping (ORM) frameworks.

After the "holidays", will we look at one of them: JPA.